

**REMARKS**

Applicants have submitted herewith a Substitute Specification. The Substitute Specification does not contain new matter. A marked-up copy of the original specification showing the matter being added to and deleted from the specification is also submitted herewith.

The Examiner is respectfully requested to approve the Substitute Specification.

As the Examiner will note, Figure 3 has been changed to Figure 3A, and Figure 3B has been added to the present application to show the feature of the present invention wherein a surface film layer is formed from the heat-melting fibers.

Claims 1-3 have been rejected by the Examiner under 35 U.S.C. § 112, first paragraph, as failing to comply with the enablement requirement as set forth on pages 3 and 4 of the present application. Also, claims 1-3 have been rejected by the Examiner under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicants regards as the invention, for the reasons set forth on page 5 of the Examiner's Office Action. These rejections are respectfully traversed.

As the Examiner will note, the claims have been amended to recite that the thin film of heat melting fiber is defined as being substantially continuous.

The expression "substantially continuous" is intended to mean that the thin film is substantially continuous to the web in the lower layer. Thus, the substantially continuous thin film of the present invention is intended to mean a thin film that appears like a film, although a hole can be visually observed such as shown in Figure A attached hereto. Figure B, attached hereto, provides further illustration of the surface of the thin film layer. As shown in the drawings (illustrations of the surface of the thin film layer) melted polymer concentrates at the intersection of the fibers. As the heating temperature is raised, low-melting polymer flows and gradually spreads among the fibers like a film. Although not a complete film without a hole, a substantially film-like body is formed because the polymer flows among the fibers. Therefore, air passage is suppressed and consequently a thin film in terms of appearance and touch is formed. As to the change in the thin film melted on the surface of each card web, in the second-heat treatment, the low melting fibers (heat-melting fibers) that did not initially melt, will melt at this time, and the low-melting fibers (heat-melting fibers) at the intersection of the fibers that had already melted and fluidized will melt again. In this manner, the fibers serve to adhere to other stacked card webs both above and below, with the property of the thin film being maintained.

As to the integration with neighboring layers of adjacent card webs, the web on the side opposite (back) to the thin film layer is not applied with much

heat and not all low-melting fibers (heat-melting fibers) in the thin film layer will melt. Accordingly, an environment allowing for fusion is still maintained. In other words, the low-melting fibers (heat-melting fibers) contained in the thin film layer in the back side web can fuse and adhere to one another. Therefore, if the thin film layer and the web are alternatively stacked and a uniform heat-treatment is performed, the low melting fibers (heat-melting fibers) contained in the web will melt and adhere so as to create a thermal insulating material (see Figure C, attached hereto). As to whether or not the synthetic fibers which make up the matrix fiber are substantially the same as the heating-melting fibers, it can be stated that the matrix fiber is substantially the same as the heat-melting fiber. That is to say, the material mainly used as the heat-melting fiber (low-melting fiber) is a "sheath-core type conjugated cotton" utilizing isophthalic acid copolymer polyester as the sheath and PET (polyethylene terephthalate) as the core.

It is believed that the above explanations clearly demonstrate that original claims 1-3 satisfy both the enablement requirement and the definiteness requirement required by 35 U.S.C. § 112.

Claims 1-3 have been further rejected by the Examiner under 35 U.S.C. § 102(b) as being anticipated by or, in the alternative under 35 U.S.C. § 103(a) as being obvious over Fukuhara et al. (EP 1 059 393). This rejection is respectfully traversed.

The Fukuhara et al. reference discloses a thermal insulating material involving a tentative fusing and heating stage and a heating stage in a steam pot, and both heating stages provide a uniform heat-treatment. Thus, in the heat-treatment, the entire card web is uniformly heated, and the low-melting fibers (heat-melting fibers), among the constituent fibers, melt and adhere at the intersection with one another so as to form a fiber structural body. Here, not all, but a part of the low-melting fibers (heat-melting fibers) at the intersections, melt in the normal heat-treatment, and contribute to adhesion among the fibers. In particular, the vacuum heating, which is conducted in the steam pot, provides very uniform heating. According to the present invention, in the first heating stage, in order to form a thin film, at least one side of the card web 22 is heated so as to form a film at the surface, and the degree of fusion is gradually lowered in the direction of thickness (lower layer portion of the web). In addition, a hot plate or a heating roller 24 can be placed in contact with the card web 22 so as to form a thin film on the surface of the card web 22. In other words, in the present invention, a heat-treatment which is not uniform in the direction of the thickness of the card web is intended, and not a surface treatment as is the case of the present invention. In addition, the thickness of the thin film can be increased merely by increasing the amount which is melted, for example, by raising the heating temperature or decreasing the distance between the card web and the heating source. As shown in the

drawings illustrated the surface of the thin film layer, the melted polymer concentrates at the intersection of the fibers. As the heating temperature is raised, the low-melting polymer flows and gradually spreads among the fibers like a film. Although not a complete film without a hole is formed, a substantially film-like body is formed because the polymer flows among the fibers. Therefore, air passage is suppressed and consequently, a thin film in terms of appearance and touch is formed.

The second heating stage is similar to that of the reference, whereby after the web is stacked, the stack is uniformly heated and fused so as to create a thermal insulating material. In summary, it can be stated that the thermal insulating material of the prior art does not produce a substantially continuous thin film, because the entire composite is uniformly heated, and accordingly, does not suggest a thermal insulating material as defined by the present invention.

As the Examiner will note, claims 6-8 have been added to the present application. Since newly added claim 7 is directed to a thermal insulating material, it should be properly included with original claims 1-3, presently under consideration. It is understood that claims 6-8 which are directed to the method, will be properly included with method claims 4 and 5 and thus, withdrawn from consideration as not being readable on the elected invention.

Accordingly, in view of the above amendments and remarks, reconsideration of the rejections and allowance of the claims of the present application are respectfully requested.

**Conclusion**

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Mr. Joseph A. Kolasch (Reg. No. 22,463) at the telephone number of the undersigned below, to conduct an interview in an effort to expedite prosecution in connection with the present application.

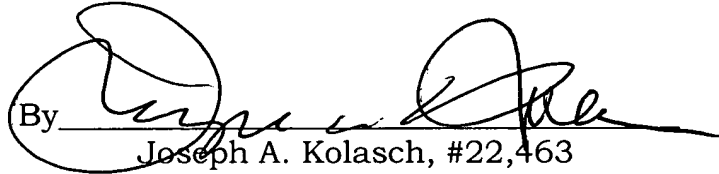
Pursuant to the provisions of 37 C.F.R. §§ 1.17 and 1.136(a), the Applicant respectfully petitions for a two (2) month extension of time for filing a response in connection with the present application and the required fee of \$420.00 is attached hereto.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. §§ 1.16 or

1.17; particularly, extension of time fees.

Respectfully submitted,

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By   
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Attachments:      NEW Abstract of the Disclosure  
                         Two (2) Sheets of Replacements Drawings  
                         Substitute Specification (clean version)  
                         Substitute Specification (marked up version)  
                         Two (2) Sheets of reference information (Figs. A-C)

**AMENDMENTS TO THE DRAWINGS**

Attached hereto is(are) two (2) Replacement Sheet(s) corrected formal drawings that comply with the provisions of 37 C.F.R. § 1.84. The drawings incorporate the following drawing changes:

**Figure 3 has been amended to read as “FIG. 3A”, and wherein reference numeral 100 has been included; and**

**Figure 3B has been added.**

It is respectfully requested that the corrected formal drawings be approved and made a part of the record of the above-identified application.

Attachment: Two (2) Replacement Sheets



Fig. A

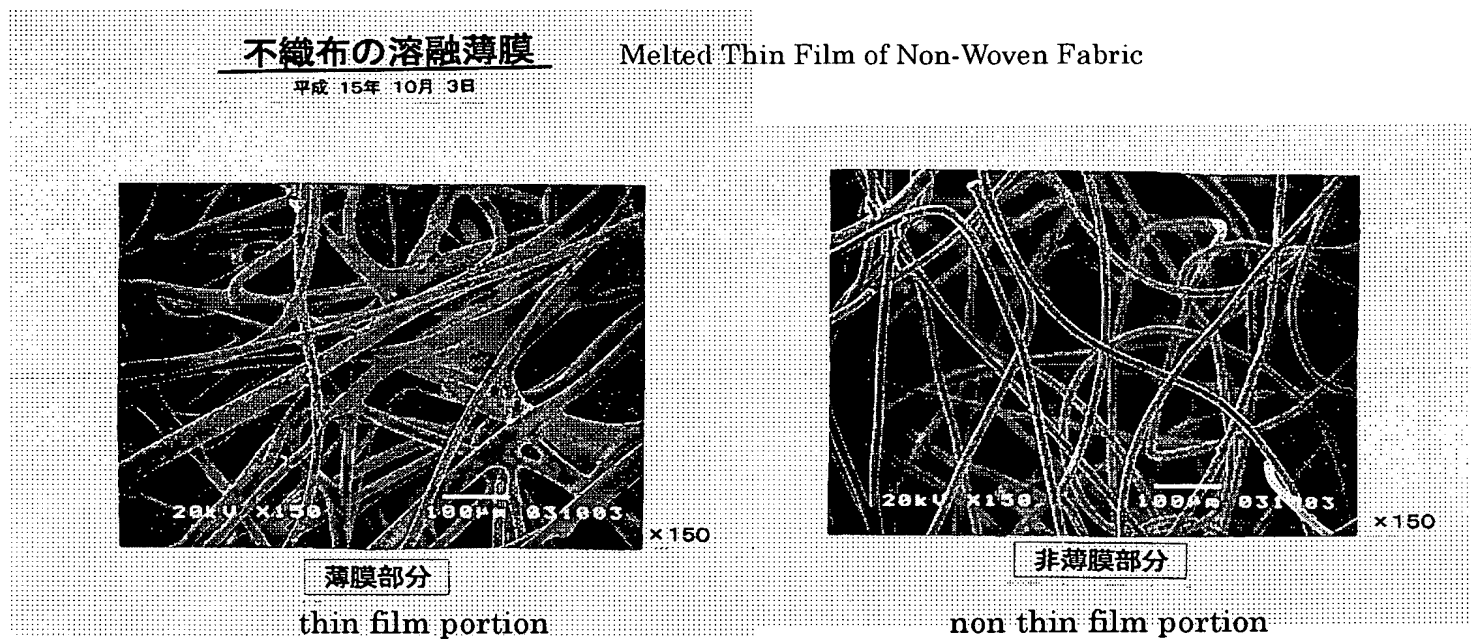


Fig. B

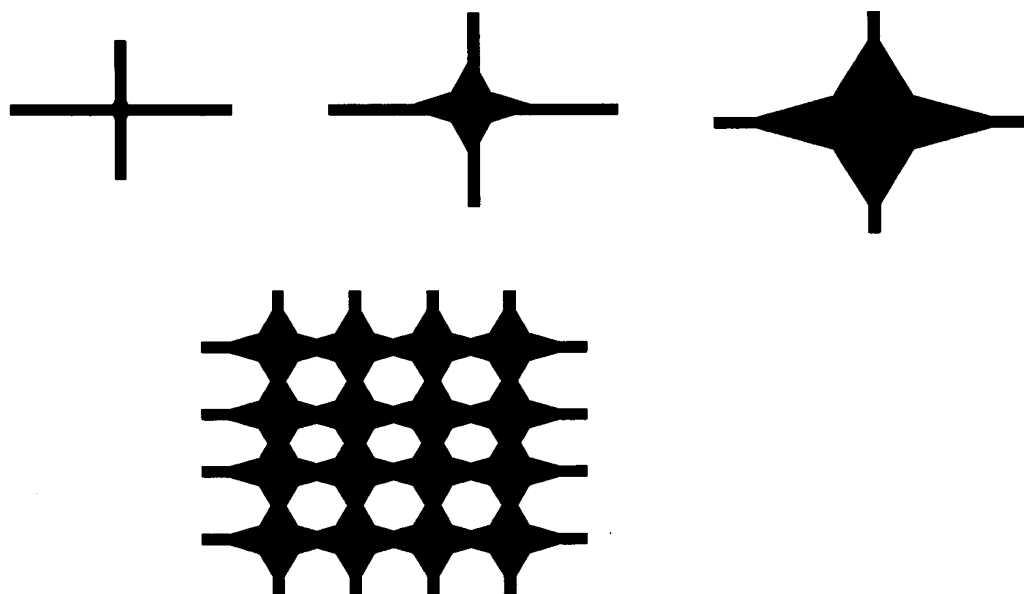
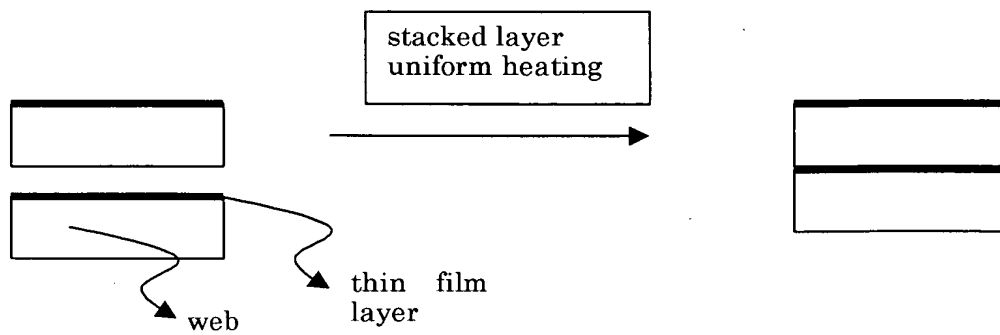


Fig. C



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~~{TITLE OF THE INVENTION~~

~~Thermal Insulating Material Formed of Non-Woven Fabric and Method of Manufacturing the Same}~~ **[A THERMAL INSULATING MATERIAL FORMED OF NON-WOVEN FABRIC AND A METHOD OF MANUFACTURING THE SAME]**

## BACKGROUND OF THE INVENTION

~~{Field of the Invention~~~~}~~**[FIELD OF THE INVENTION**

**[0001]]**The present invention relates to a thermal insulating material, and more specifically, to a thermal insulating material for ~~{housing use}~~ **[home insulation]** using a polyester fiber and the like.

~~{Description of the Background Art~~~~}~~**[DESCRIPTION OF THE BACKGROUND ART**

**[0002]]**In recent years, attempts are made to reduce carbon-dioxide emissions for the purpose of preventing global warming. One of the strategies involves improving the heating and cooling efficiencies of houses. Thus, there is a demand for a thermal insulating material that has **[a]** higher thermal insulation property that satisfies the standard for energy conservation of the next generation.

**[[0003]]** International Publication No. WO 99/43903 discloses a

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thermal insulating material using a fiber. This thermal insulating material is one that has a plurality of card webs stacked one on top of another. A card web includes a polyester fiber, a sheath-core type composite fiber that utilizes a low melting point component for the sheath having a lower melting point than the core, and a fused portion in which these fibers are fused and stuck together by melting of a sheath portion of the sheath-core type composite fiber.

**[[0004]]** Since the fibers are fused together by the melting of the sheath portion, this thermal insulating material undergoes little change over time in shape and in thermal insulation rate when compared with conventional thermal insulating materials such as glass wool and rock wool. The thermal insulating material can be easily cut in a direction in which card webs are stacked so that it can be easily worked upon at a housing construction site.

**[[0005]]** The thermal insulating material disclosed in this publication, however, does not sufficiently satisfy the thermal insulation rate based on the standard for energy conservation of the next generation (i.e., high thermal insulation rate means low thermal conductivity). Thus, the thermal insulation rate that satisfies the above-mentioned standard is being achieved by increasing the thickness of a thermal insulating material or by increasing the fiber density of a non-woven fabric forming the thermal insulating material.

**[[0006]]** When the thickness of the thermal insulating material is

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increased, the above-mentioned standard may be satisfied, but the cost may increase or the thermal insulating material may no longer conform to the standards of construction materials for housing use. When the fiber density of the non-woven fabric forming the thermal insulating material is increased, the above-mentioned standard may be satisfied, but the cost increases.

## SUMMARY OF THE INVENTION

**[[0007]]** An object of the present invention is to provide a thermal insulating material that achieves **[a]** high thermal insulation rate and a method of manufacturing such a thermal insulating material without incurring an increase in the cost.

**[[0008]]** Another object of the present invention is to provide a thermal insulating material that achieves **[a]** high thermal insulation rate by effectively blocking airflow and a method of manufacturing such a thermal insulating material.

**[[0009]]** A further object of the present invention is to provide a thermal insulating material that achieves **[a]** high thermal insulation rate using fiber and a method of manufacturing such a thermal insulating material.

**[[0010]]** A still further object of the present invention is to provide a thermal insulating material that utilizes fiber and that does not deform easily and a method of manufacturing such a thermal insulating material.

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**[[0011]]** An even further object of the present invention is to provide a thermal insulating material suitable for a wall surface of a house and a method of manufacturing such a thermal insulating material.

**[[0012]]** According to one aspect of the present invention, the thermal insulating material is made of non-woven fabric including multiple types of fiber. The thermal insulating material includes a matrix fiber, a heat-melting fiber, and a thin film formed by the heat-melting fiber being fused at a surface of the thermal insulating material.

**[[0013]]** The matrix fiber and the heat-melting fiber are entangled. Thus, very small air gaps are formed inside the thermal insulating material, while at the same time, it becomes less easy for the overall shape of the thermal insulating material to undergo deformation. Air is held in the air gaps, thereby achieving thermal insulation effect. A surface of the thermal insulating material is heated to form a thin film in which the heat-melting fibers on the surface are fused and stuck together. The thin film blocks the flow of air held within the thermal insulating material and increases the thermal insulation effect even further. As a result, a thermal insulating material that achieves high thermal insulation rate can be provided without incurring the increase in the cost.

**[[0014]]** According to the above[, in] one aspect of the present invention, the thermal insulating material has two or more card webs, each including multiple types of fiber, stacked one on top of another. Each card web includes a matrix fiber, a heat-melting fiber, and a thin film formed by

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the heat-melting fiber being fused on a surface of the card web. Each card web has heat-melting fibers fused together within the card web, and the card webs are integrated by **[the]** fusing and sticking together of the heat-melting fibers.

**[[0015]]** The heat-melting fiber on a surface of a card web forms a thin film on each of the surfaces of the two or more card webs ~~{being stacked}~~ **[arranged as a stack]**. The heat-melting fiber inside a card web integrates the card web. The heat-melting fibers between card webs integrate the card webs. Consequently, a thin film formed on a surface of a card web blocks the flow of air that exists inside the two or more card webs, thereby increasing the thermal insulation effect even further. Through the integration of the card webs, it becomes less easy for the overall shape of the thermal insulating material to undergo deformation. As a result, a thermal insulating material that achieves **[a]** high thermal insulation rate can be provided without incurring ~~{the}~~ **[an]** increase in ~~{the}~~ cost.

**[[0016]]** More preferably, the thermal insulating material according to the ~~{above one aspect of the}~~ present invention does not conduct heat easily in a direction **[in which]** the card webs are stacked.

**[[0017]]** The heat-melting fiber forms a thin film on a surface of a card web. Since the direction in which card webs are stacked runs parallel to the direction in which thermal insulation is effected, the thin film formed on the surface of a card web blocks the flow of air that exists within two or more card webs, thereby making it less easy for heat to conduct in the direction in

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which the card webs are stacked. By using this thermal insulating material for a wall surface of housing, for instance, heat is not easily conducted from indoors to outdoors, and vice versa.

**[[0018]]** According to another aspect of the present invention, a method of manufacturing a thermal insulating material includes the steps of mixing a matrix fiber with a heat-melting fiber, forming the mixed fibers into a card web, and heating a surface of the card web to fuse the heat-melting fiber on the surface of the card web to form a thin film on the surface of the card web.

**[[0019]]** A card web is formed in which the matrix fiber and the heat-melting fiber are mixed. The matrix fiber and the heat-melting fiber are entangled so that very small air gaps are formed inside the thermal insulating material. Air is held in the air gaps, thereby achieving thermal insulation effect. In a succeeding step, a surface of the card web is heated so that the heat-melting fiber on the surface of the card web is fused, thereby forming a thin film on the surface of the card web. The thin film blocks the flow of air held within the thermal insulating material and increases the thermal insulation effect even further. These manufacturing steps can be performed using a manufacturing apparatus arranged for the conventional manufacturing steps. As a result, a thermal insulating material that achieves high thermal insulation rate can be manufactured without incurring the increase in the cost.

**[[0020]]** According to a further aspect of the present invention, {a}



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**[the]** method of manufacturing a thermal insulating material ~~is a method of manufacturing a thermal insulating material in which~~ **[includes the step of providing a stack of]** two or more card webs, each ~~including~~ **[containing]** multiple types of fiber~~, are stacked~~. This manufacturing method includes the steps of mixing a matrix fiber with a heat-melting fiber, {  
}forming the mixed fibers into a card web, heating {a} **[the]** surface of the card web to fuse the heat-melting fiber on the surface of the card web to form a thin film on the surface of the card web, stacking two or more card webs having undergone heat treatment in the step of forming the thin film, and fusing the heat-melting fiber inside the two or more card webs stacked and fusing the heat-melting fibers between the card webs to integrate the card webs.

**[[0021]]** A card web is formed in which the matrix fiber and the heat-melting fiber are mixed. In the step of heating the surface of the card web, the heat-melting fiber on a surface of the card web fuses together and forms a thin film **[on]** the surface of the card web. In the step of stacking the card webs, the card webs are stacked. When the stacked card webs are heated, the heat-melting fibers inside and between card webs are fused. The stacked card webs are **[thus]** integrated. Consequently, the thin film formed on the surface of the card webs blocks the flow of air that exists inside the card webs, thereby increasing the thermal insulation effect even further. With the two or more card webs being integrated, it becomes less easy for

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the overall shape of the thermal insulating material to undergo deformation. These manufacturing steps can be performed using a manufacturing apparatus arranged for the conventional manufacturing steps. As a result, a thermal insulating material that achieves **[a]** high thermal insulation rate can be manufactured without incurring ~~{the}~~ **[an]** increase in the cost.

**[[0022]]** The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[[0023]]**The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

**[[0024]]**Fig. 1 is a diagram showing a step of manufacturing a non-woven fabric thermal insulating material according to a first embodiment of the present invention~~{~~  
~~}~~;

**[[0025]]**Figs. 2[, **3A**] and ~~{3}~~ **[3B]** are diagrams ~~{related}~~ **[relating]** to the description of usage of a stack thermal insulating material according to a second embodiment of the present invention[; and

**[[0026]]**~~{~~

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} Fig. 4 is a diagram in the form of a table showing the properties of the stack thermal insulating material according to the second embodiment of the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[[0027]]** The embodiments of the present invention will be described below with reference to the drawings. In the following description and throughout the drawings, the same parts are denoted by the same reference characters. The names and the functions thereof are also the same. Thus, the detailed descriptions thereof will not be repeated.

First Embodiment

**[[0028]]** A non-woven fabric thermal insulating material according to the first embodiment of the present invention will be described below. First, the fiber forming the non-woven fabric thermal insulating material will be described.

**[[0029]]** In a case where synthetic fiber is employed as the matrix fiber forming the non-woven fabric thermal insulating material, the polymer is not limited to any particular type. For instance, aromatic polyester such as polyethylene terephthalate and polybutylene terephthalate, aliphatic polyester such as polylactic acid and polycaprolactam, polyolefin such as polypropylene and polyethylene, polyamide such as Nylon 6 and Nylon 66, and copolymer thereof may be used. In addition, a mixture of two or more

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types of these fibers may also be used.

**[[0030]]** In order **[to]** efficiently ~~{to}~~ recycle the thermal insulating material, a polymer of polyester-type is more preferred. As a polyester fiber, polyethylene terephthalate, polyhexamethylene terephthalate, polytetramethylene terephthalate, poly 1,4-dimethylcyclohexane terephthalate, polyhydrolactone, or copolymerized esters thereof may be used. A composite fiber thereof produced by conjugate spinning may also be used. A side-by-side composite fiber made of two kinds of polymers having different heat shrinkage rates is preferred since it develops a three-dimensional structure due to spiral crimp. In this case, a hollow fiber having hollowness of 5 to 30 percent is particularly preferred.

**[[0031]]** Preferably, the fineness of the matrix fiber is 1 to 30 dtex and its cut length is 25 to 150 mm.

**[[0032]]** A synthetic fiber is used as the heat-melting fiber forming the non-woven fabric thermal insulating material. In this case, the polymer is not limited to any particular type. For instance, aromatic polyester such as polyethylene terephthalate and polybutylene terephthalate, aliphatic polyester such as polylactic acid and polycaprolactam, polyolefin such as polypropylene and polyethylene, polyamide such as Nylon 6 and Nylon 66, and copolymer thereof may be used. In addition, a mixture of two or more types of these fibers may also be used.

**[[0033]]** The heat-melting fiber may be a single-constituent fiber formed from any one of the above-described polymers. The heat-melting

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fiber may also be sheath-core type composite fiber. In this case, a usual polyester fiber constituent is used for the core, while low melting-point polyester, polyolefin, polyamide or the like is used for the sheath. The core component and the sheath component are combined such that the difference between the melting points of the core component and the sheath component becomes 30°C or greater. By using such **[a]** composite fiber, heat-fusing ~~{feature}~~ **[features]** can be achieved while retaining the form-maintaining feature of the core component. Since the overall shape of the thermal insulating material would not be easily deformed, it is particularly preferable when it is to be used for a long period of time as in the case of the thermal insulating material. Preferably, the fineness of the heat-melting fiber is 2 to 20 dtex and its cut length is 25 to 76 mm.

**[[0034]]** The card web used for the non-woven fabric thermal insulating material according to ~~{the}~~ **[a]** first embodiment is preferably one obtained by mixing a matrix fiber and a heat-melting fiber at a weight ratio of 95 through 40 to 5 through 60.

**[[0035]]** The non-woven fabric thermal insulating material according to the first embodiment is produced by subjecting to a first heat treatment with far infrared rays and the like, a card web obtained by mixing a matrix fiber with a sheath-core composite fiber that utilizes a low melting point component for the sheath having a lower melting point than the core. The first heat treatment forms a thin film on a surface of the card web. The detail of this manufacturing method will be described below with reference

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to Fig. 1.

**[[0036]]** An apparatus for manufacturing the thermal insulating material includes a hopper 10 for opening and mixing the matrix fiber and the heat-melting fiber, a conveyor belt 14 for transporting the mixed fiber mixture 12, a feed roller 16 for guiding ~~{,}~~ **[the fiber mixture]** to a carding machine, ~~{fiber mixture 12 transported by conveyor belt 14,}~~ a cylinder roller 18 for carding and forming **[the]** fiber mixture 12 into a web, and a doffer 20 for **[outwardly]** transporting ~~{outward}~~ a card web 22 carded by cylinder roller 18. As it moves ~~{toward}~~ **[in]** the direction of ~~{an}~~ arrow A, **[the]** fiber mixture 12 is processed to form card web 22.

**[[0037]]** The apparatus further includes a transporting conveyor 26 for transporting **[the]** card web 22 including the matrix fiber and the heat-melting fiber, a heater 24 disposed opposite to **[the]** transporting conveyor 26 for heating ~~{a}~~ **[the]** surface of **[the]** card web 22, and a cooling roller 28 provided on the exit side of heater 24 for cooling **[the]** card web 22 as well as compressing **[the]** card web 22 to a prescribed thickness. As it moves ~~{toward}~~ **[in]** the direction of ~~{an}~~ arrow B, **[the]** card web 22 is processed to form a non-woven fabric thermal insulating material 30.

**[[0038]]** Heater 24 may be any heater that can heat a surface of **[a]** card web 22, and is not limited to any particular type. Heater 24 effects non-uniform heat treatment from a surface of card web 22 toward the direction of the thickness of card web 22. Heater 24 fuses the heat-melting fiber on the surface to form a thin film on the surface of card web 22. For

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instance, an infrared heater may be used as such **[a]** heater 24. Indirect heating by radiant heat of the infrared heater is effected from one side of card web 22. In this case, the radiant heat does not reach into the central portion ~~{in}~~ **[of]** the ~~{direction of}~~ thickness of card web 22 and to the back side of card web 22 so that the temperatures thereat do not rise. Thus, the degree of fusion becomes gradually lower. In this manner, the thin film is formed only on the surface.

**[[0039]]** Heater 24 may be a hot plate or a heating roller that is brought into contact with card web 22. A thin film can be formed on a surface of **[the]** card web 22 using such a hot plate or a heating roller.

**[[0040]]** The heating temperature achieved by heater 24 (the surface temperature of card web 22) is preferably in a range of 110 to 220°C. A temperature within this temperature range is sufficient to melt the polymer of the heat-melting fiber on the surface to form a thin film, ~~{and affects}~~ **[while affecting]** the matrix fiber only a little. Thus, changes in physical properties and the like caused by polymer degradation according to **[the]** heat history to which the matrix fiber is subjected can be suppressed.

**[[0041]]** In ~~{the}~~ **[a]** first heat treatment, the quantity of heat that card web 22 receives can be changed so as to vary the degree of melting of the heat-melting fiber. The feed speed in the direction of arrow B of the card web can be changed to vary the heating time and thus the degree of the melting.

**[[0042]]** Non-woven fabric thermal insulating material 30 produced by

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the manufacturing apparatus described above may be used by itself as a thermal insulating material, or a plurality of non-woven fabric thermal insulating materials 30 may be stacked and used as the thermal insulating material. The thin film formed on a surface of non-woven fabric thermal insulating material 30 blocks the flow of air contained in non-woven fabric thermal insulating material 30, thereby achieving **[a]** high thermal insulation effect.

**[[0043]]** As described above, in the non-woven fabric thermal insulating material according to the first embodiment, a thin film can be formed on a surface of the non-woven fabric by the first heat treatment. This thin film can block the flow of air within the thermal insulating material. No special apparatus is required in order to form the thin film. Consequently, a thermal insulating material that achieves high thermal insulation rate can be provided without incurring the increase in the cost.

Second Embodiment

**[[0044]]** A stack **[of]** thermal insulating material according to ~~the~~ **[a]** second embodiment of the present invention will be described below. A fiber forming the stack **[of]** thermal insulating material according to the second embodiment is the same as that which forms the non-woven fabric thermal insulating material according to the first embodiment. Thus, the detailed descriptions thereof will not be repeated here.

**[[0045]]** The stack **[of]** thermal insulating material according to the



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second embodiment is manufactured by stacking one on top of another a plurality of non-woven fabric thermal insulating materials 30 produced by performing the first heat treatment in the first embodiment. A manufacturing apparatus for the stack **[of]** thermal insulating material includes a stacking machine and a second heat treatment machine in addition to the manufacturing apparatus of the first embodiment. The stacking machine stacks a plurality of non-woven fabric thermal insulating materials 30 having undergone the first heat treatment to form a stack body. The second heat treatment machine performs a second heat treatment to the stack body and fuses the heat-melting fiber inside each non-woven fabric thermal insulating material 30 and the heat-melting fibers between the plurality of non-woven fabric thermal insulating materials 30. Details of the manufacturing apparatus will be described below.

**[[0046]]** A prescribed number (ten sheets to twenty sheets) of non-woven fabric thermal insulating materials 30, each produced to have a prescribed weight per unit area, a prescribed density, and a prescribed shape by the first heat treatment, are stacked to form a stack body.

**[[0047]]** The stack body is held under compression between plates such as metal plates having good thermal conduction property, and is erected in an upright condition and subjected to heat treatment within a steam pot. Then, the stack body while held under compression is rotated by 90 degrees and is subjected to heat treatment such that the load does not affect the stack body in a direction of its thickness.

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**[[0048]]** In the second heat treatment, conditions of the heat treatment is determined such that sufficient heat reaches inside the stack body so as to fuse together the heat-melting fiber within the stack body and to fuse the heat-melting fibers between non-woven fabric thermal insulating materials 30. In particular, the conditions of the heat treatment is determined such that the thin film formed on a surface of non-woven fabric thermal insulating material 30 by the first heat treatment is maintained.

**[[0049]]** By subjecting the stack body to heat treatment while holding it under compression, a repulsion force in the horizontal direction (direction opposite to the direction of compression) is created in the fiber inside the stack body. Consequently, **[the]** moving of the fiber toward the lower part of the thermal insulating material due to the self-weight of the fiber can be prevented. The second heat treatment is preferably performed by introducing steam of 98 kPa or greater into the steam pot after having lowered the pressure inside the steam pot to 100 kPa or greater. A plate used for holding the stack body under compression is preferably a perforated plate.

**[[0050]]** By performing the second heat treatment, a stack body of a desired density can be manufactured regardless of the thickness of the stack body. For instance, even when the weight per unit area of card web 22 and the number of card webs to be stacked are the same, a product of low density can be produced by not compressing the card webs too strongly during heat treatment, while a product of high density can be produced by

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compressing the card webs strongly during heat treatment. Even with a thick stack body having a thickness of 1000 mm, for example, fusing of the heat-melting fiber inside can be uniformly effected. Using the above-described manufacturing apparatus, an excellent product with an overall fine hand and feel can be efficiently manufactured. A product of a desired density with a density variation in the range of within  $\pm 5$  percent can be easily manufactured.

**[[0051]]** By performing such second heat treatment, a stack thermal insulating material according to the second embodiment can be manufactured. In the stack **[of manufactured]** thermal insulating material ~~{manufactured}~~, a plurality of non-woven fabric thermal insulating materials 30 are stacked, and the heat-melting fiber is fused inside the stack **[of]** thermal insulating material, ~~{while}~~ **[whereby]** a thin film is formed on a surface of each non-woven fabric thermal insulating material 30 inside the stack **[of]** thermal insulating material.

**[[0052]]** In addition, when manufacturing the stack **[of]** thermal insulating material according to the second embodiment, the second heat treatment can be performed by rotating the stack body such that its weight is not localized in one direction.

**[[0053]]** A usage of the stack **[of]** thermal insulating material of the second embodiment will be described with reference to Fig. 2. A wall panel 40 for housing use in which the stack **[of]** thermal insulating material of the second embodiment is used includes a framework assembled by horizontal

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frames 42 and vertical frames 44, an exterior board element 46 provided on the exterior side of the framework, an interior board element 50 provided on the interior side of the framework, a stack thermal insulating material 48 inserted in the inner space of the framework, a moisture-proof sheet 52 provided between interior board element 50 and stack thermal insulating material 48, and an exterior member 54.

**[[0054]]** The components of the framework are produced by lumber and bonded wood. The lumber is blocks of wood having cross sections of 50.8 mm × 101.6 mm (2 inches × 4 inches), 50.8 mm × 152.4 mm (2 inches × 6 inches), and so on based on various standards. ~~{A}~~ **[The]** thickness of thermal insulating material 48 is determined according to the dimension of the wood block. An interval between vertical frames 44 positioned on panel 40 is normally 455 mm from center to center, but may be changed according to ~~{a}~~ structural ~~{requirement}~~ **[requirements]**. Horizontal frames 42 include an upper frame as well as the lower frame being shown.

**[[0055]]** A structural plywood having a thickness of about 7 to 12 mm and the like may be used as exterior board element 46, and a plasterboard having a thickness of about 9 to 15 mm and the like may be used as **[the]** interior board element 50.

**[[0056]]** The apparent thickness of stack thermal insulating material 48 according to the second embodiment is about 90 mm matching the width of the framework ~~{{a}}~~**[[the]** thickness of **[the]** horizontal frame 42 or **[the]** vertical frame 44). ~~{Stack}~~ **[The stack of]** thermal insulating material 48 is

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inserted into the framework to make complete contact with moisture-proof sheet 52 mentioned above as well as with **[the]** exterior board element 46. In other words, it is constructed such that **[the]** stack **[of]** thermal insulating material 48 completely fills the space between the walls formed by the framework members.

**[[0057]]** As shown in ~~{Fig. 3,}~~ **[Figs. 3A and 3B,]** when **[a]** stack **[of]** thermal insulating material 48 is used, it is preferable that the direction in which **[the]** non-woven fabric thermal insulating materials 30 are stacked runs parallel to the direction of the wall thickness (direction in which **[the]** thermal insulation is to be effected). In this manner, the thin film **[48A shown in detail in Figure 3B as cut away portion 100,]** formed on the surface of **[the]** non-woven fabric thermal insulating material 30 blocks the airflow in the directions of **[the]** heat insulation (directions indicated by an arrow X-Y).

**[[0058]]** Fig. 4 shows the properties of the stack thermal insulating material according to the second embodiment. The first and second heat treatment were performed on card webs having a fiber composition shown in Fig. 4 and stack thermal insulating materials (first sample, second sample) were produced.

**[[0059]]** Thermal conductivity in an X-Y direction and in a Z-W direction in Fig. ~~{3}~~ **[3A]** was measured with regard to the stack **[of]** thermal insulating material manufactured under the above-described conditions shown in Fig. 4. The measuring method according to "JIS A 1412-1994 Test

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Methods for Thermal Transmission Properties of Thermal Insulations, 5.1 Plate Direct Method" was employed.

**[[0060]]** As a result of the measurement, the thermal conductivity in the XY direction of the first sample was 0.038 (W/m•K) and the thermal conductivity in the ZW direction of the first sample was 0.042 (W/m•K), while the thermal conductivity in the XY direction of the second sample was 0.039 (W/m•K) and the thermal conductivity in the ZW direction of the second sample was 0.044 (W/m•K). Both the first and second samples were found to satisfy a rank C (0.040 to 0.035 (W/m•K)) of the standard for energy conservation of the next generation.

**[[0061]]** As described above, in addition to the effects obtained by the first heat treatment, the non-woven fabric thermal insulating material according to the second embodiment achieves through the second heat treatment uniform fusing inside a card web forming the non-woven fabric thermal insulating material, which eliminates variation in density so that a non-woven fabric thermal insulating material with an overall fine hand and feel and superior external appearance can be provided. The second heat treatment effects fusing between card webs forming the non-woven fabric thermal insulating material so that a plurality of card webs can be integrated. As a result, the thermal insulating material that achieves **[a]** high thermal insulation rate can be provided without incurring ~~{the}~~ **[an]** increase in the cost.

**[[0062]]** Although the present invention has been described and

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illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

~~{WHAT IS CLAIMED IS:~~

~~1. A thermal insulating material made of non woven fabric including multiple types of fiber, comprising:~~

~~a matrix fiber;~~

~~a heat melting fiber; and~~

~~a thin film formed by said heat melting fiber being fused on a surface of said thermal insulating material. 2. A thermal insulating material having two or more card webs, each including multiple types of fiber, stacked one on top of another, wherein~~

~~each of said card webs includes~~

~~a matrix fiber,~~

~~a heat melting fiber, and~~

~~a thin film formed by said heat melting fiber being fused on a surface of each of said card webs,~~

~~each of said card webs having said heat melting fibers fused together within the card web, and~~

~~said card webs being integrated by fusing of said heat melting fibers. 3. The thermal insulating material according to claim 2, which does not conduct heat easily in a direction said card webs are stacked. 4. A method of~~

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~~manufacturing a thermal insulating material, comprising the steps of:~~  
~~mixing a matrix fiber with a heat melting fiber;~~  
~~forming mixed fibers into a card web; and~~  
~~heating a surface of said card web to fuse the heat melting fiber on the~~  
~~surface of said card web to form a thin film on the surface of said card web.~~

~~5. A method of manufacturing a thermal insulating material in which two or~~  
~~more card webs, each including multiple types of fiber, are stacked,~~  
~~comprising the steps of:~~

~~mixing a matrix fiber with a heat melting fiber;~~  
~~forming mixed fibers into a card web;~~  
~~heating a surface of said card web to fuse said heat melting fiber on the~~  
~~surface of said card web to form a thin film on the surface of said card web;~~  
~~stacking two or more of said card webs having undergone heat treatment in~~  
~~the step of forming said thin film; and~~  
~~fusing the heat melting fiber inside said two or more card webs stacked and~~  
~~fusing the heat melting fiber between said card webs to integrate said card~~  
~~webs.~~  
~~ABSTRACT OF THE DISCLOSURE~~

~~A thermal insulating material is formed by stacking two or more card webs,~~  
~~and each card web includes a matrix fiber, a heat melting fiber, and a thin~~  
~~film formed by the heat melting fiber being fused on a surface of the card~~  
~~web. Each card web has the heat melting fiber within the card web fused~~  
~~together, and the card webs are integrated by fusing of the heat melting~~  
~~fibers between the card webs. The thermal insulating material is used such~~



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~~that the direction in which the card webs are stacked runs parallel to the  
direction in which thermal insulation is effected.}~~